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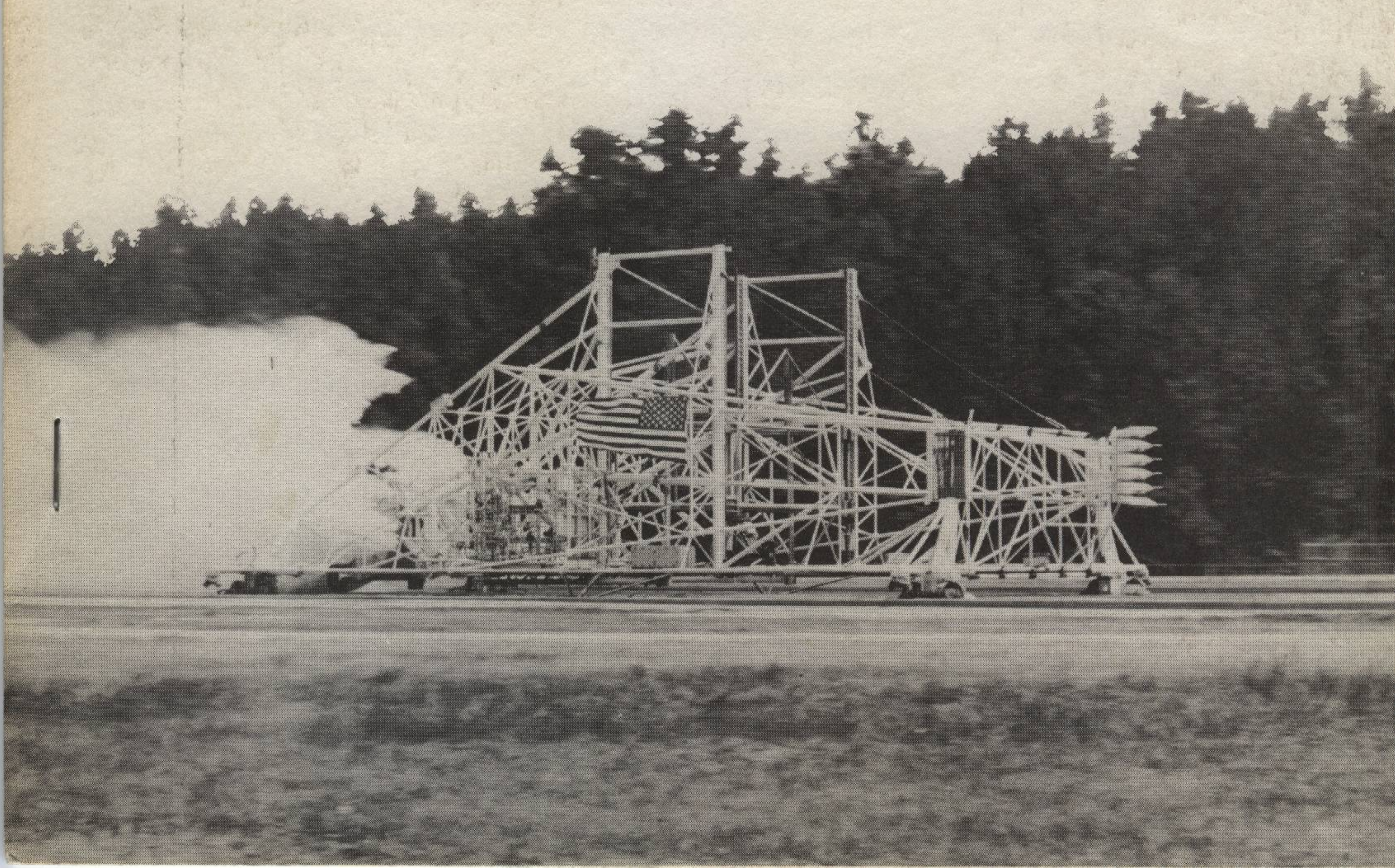
NASA Langley's Unique
Aircraft Landing Dynamics Facility



NASA Langley's Unique Aircraft Landing Dynamics Facility

The Aircraft Landing Dynamics Facility (ALDF), formerly called the Landing Loads Track, is a unique national test facility for evaluating a variety of aircraft landing gear systems and components under closely controlled conditions. The facility originally became operational in 1956 and a three-year project to update and enhance its capabilities was completed in 1985. Testing at this facility has advantages over flight testing because of safety, economy, parameter control, and versatility. Essentially any conventional landing gear and some new, advanced concepts can be mounted on the test carriage for evaluation. The facility, pictured from the test carriage propulsion end in Figure 1, consists of a concrete runway test surface with a pressurized water-jet propulsion system at one end and a cable arrestment system to slow the test carriage to a stop at the far end. A truss-structure carriage which carries the test article is propelled down the track on steel rails. The original facility had a maximum carriage speed and track length of 110 knots and 2200 feet, respectively. The upgrade project doubled the maximum carriage speed to 220 knots and extended the track length to 2800 ft. A new carriage was designed and constructed to accommodate large test articles and withstand high acceleration loads. A brief description of the three main components of this facility, namely, the propulsion system, the new test carriage, and the arrestment system is given in the following sections and the scope of research applications is indicated.

Propulsion System

The propulsion system used to propel the carriage down the track is shown in the foreground of Figure 1. It consists of an L-shaped vessel that holds 26,000 gallons of water, three air storage tanks pressurized to a maximum of 3150 psi, and a high-speed shutter valve which controls the water jet duration. The high pressure air is carried through a manifold up through the goose-necked pipe to the top of the L-vessel where the compressed air meets the water level in the vertical portion of the L-vessel. The 18 inch-diameter water jet nozzle opening is controlled by the special high-speed shutter valve mounted on the lower horizontal end of the L-vessel. A spherical valve body was chosen to contain the high pressure water with an inner shutter used to maintain a water tight seal between runs. The internal nozzle is centrally positioned within the

20 in. valve body opening and provides a smooth contour from the end of the L-vessel. During a typical catapult, the high-speed shutter valve opens in approximately 0.3 seconds and remains open for a preselected dwell time to obtain the desired speed. The shutter valve then closes in approximately 0.6 seconds. During a test run the water contained in the vertical leg of the L-vessel is displaced to the horizontal leg allowing flow continuity to be maintained. At a maximum pressure of 3150 psi, the 18 inch-diameter water jet produces a thrust of over 2 million pounds on the high-speed carriage creating a peak acceleration of 20 g's during the 400 feet of catapult stroke. The photograph in Figure 2 captures the carriage and water jet during a maximum speed catapult run. Mounted downstream from the high-speed shutter valve is a flow straightener structure used to direct the water jet downward and into the carriage reaction bucket during valve opening. After the valve is fully open the jet shoots through the flow straightener without touching it. The new test carriage can accelerate from zero velocity to 220 knots in 400 ft of track distance and in only 2 seconds.

New Test Carriage

The 58 ton carriage, shown in Figure 3, is constructed of tubular steel members and overall dimensions are 70 ft. long, 30 ft. wide, and 30 ft. high. At the back of the carriage is the water jet reaction bucket, 10 ft. high and 8 ft. wide. The water jet enters near the top of the bucket, turns through an angle of 170 degrees, and the momentum exchange involved in this process provides the carriage thrust. The drop fixture, which is located the central open bay area of the carriage, is used to mount most test articles. Details of the instrumented test tire dynamometer attached to the drop fixture are given in Figure 4. The drop fixture is positioned between four vertical rails within the open bay, and two hydraulic lift cylinders are used to raise and lower the test article. Four additional hydraulic cylinders are used to apply required vertical loads on the test article. This central open bay, 40 ft. long and 20 ft. wide, permits testing of a wide variety of test article shapes and sizes. The hydraulic system on the near side of the carriage shown in Figure 3 is used for positioning the drop carriage, applying loads, obtaining sink speeds up to 20 ft/sec, and for simulating effects of aircraft wing lift on tire loading. The outriggers located at each corner of the carriage are sliders that run under two hold-down rails at the propulsion end of the track. The hold-down slides are designed to hold the carriage on the main rails during the catapult stroke when upward force vectors might cause the carriage to be lifted off the rails. At the front of the carriage is the nose block which has five V-grooves to capture the five arresting gear cables that bring the carriage to a stop at the end of the 1800 ft. test section. Because of the high "g" loading on the carriage during the initial catapult stroke, the test parameter measurements are recorded using a telemetry system. The data signals are routed through the instrumentation box shown in Figure 3 and telemetered to the computer data room in the ALDF control building at the propulsion end of the track. A pulse-code modulator (PCM) decommutator converts the received carriage data into a 28 channel, 12-bit parallel format. These data are sent to a 16 megabyte internal memory computer with 1 gigabyte data storage capacity. This computer records test data runs, produces post-run time history plots and various cross plots for analysis. The output of the PCM decommutator is also sent to a monitor and a chart recorder which has up to 16 channels for display in real time or playback mode.

Arrestment System

The carriage arrestment system, shown in Figure 5, is vital to the facility operation. Located 2200 ft. down the track from the water jet nozzle, the system includes five arresting gear engines mounted in a concrete foundation on each side of the track. The sketch in Figure 6 provides additional hardware details of this installation. The system is a water twister type where each engine contains a tub that holds a mixture of water and antifreeze. The tubs have stator vanes on the inside at both the bottom and top surfaces. Rotor vanes are attached to the rotating shaft that protrudes through the top of the tub. A spool on this tub shaft contains the nylon tape, 8 in. wide, approximately 3/8 in. thick and 485 ft. long, which is connected to a cable that stretches across the track and is coupled to a similar tape/engine arrangement on the other side (see Figure 6). As the nose block pulls out the tapes, the rotor vanes churn the water in the tub and this churning action dissipates the kinetic energy of the carriage. This system is capable of stopping the carriage in 500 ft. or less with only 3 of the arresting cables operational. The carriage is extricated from the cables following an arrestment by the combined action of a tug vehicle coupled to the front corner of the carriage and the arresting gear engines operating in the tape/cable rewind mode. To permit overnight storage of the carriage in the calibration building at the far end of the facility, electric motor-driven elevators on the pendant support gantry towers (see Figure 6) permit raising the tape/cables high enough to clear the test carriage.

Research Applications

The initial research program conducted using the upgraded ALDF involved measuring Shuttle Orbiter tire friction and wear performance on a simulated Kennedy Space Center runway surface under a variety of operational conditions. Other research has included evaluating frictional characteristics of radial and H-type aircraft tires for comparison with conventional bias ply tires. This program was supported by the Federal Aviation Administration (FAA), U. S. Air Force, Society of Automotive Engineers, and the U. S. tire industry. Future test plans include evaluation of the effects of different runway contaminants on tire friction capability together with exploring new tire designs and pavement treatments which offer improved aircraft ground performance. With its upgraded capability, the ALDF is uniquely equipped to conduct research on present landing gear systems under realistic operational conditions and to explore and evaluate future aircraft landing system designs.

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If additional brochure copies or further information concerning the ALDF is needed, please contact **Rodney Russell, ALDF Facility Coordinator, at 757-864-3573.**